Modeling the Mechanical and Seismic Response of Fractures

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At the micro-scale, a fracture consists of two rough surfaces in partial contact. The presence of void spaces between the asperities of contact on the fracture surfaces leads to increased deformability of the fracture, as a result of which fractures have a significant influence on the seismic and mechanical response of rocks. Field and laboratory experiments have shown that fractures have a frequency-dependent effect on the amplitudes and travel times of waves transmitted and reflected at the fracture and that a variety of interface waves can propagate along the fracture surfaces. The amplitudes and travel times of these events are strongly influenced by the fracture stiffness, which in turn depends on the fracture surface roughness and area of contact between the fracture surfaces. Fracture stiffness increases with increasing in-situ stress because of the increasing contact area between the fracture surfaces. Typical values of fracture stiffness measured on core-sized fractures lie between 1000 GPa/m and 30,000 GPa/m, however, the stiffnesses of field-scale fractures have not, to our knowledge, been successfully measured and are thought to be significantly lower. We investigate the possibility of inverting seismic data for fracture stiffness, and hence for properties such as fracture surface geometry, area of contact, aperture and in-situ stress. A fundamental investigation of the relationship between these properties is required.

We are using a particle-based numerical modelling scheme (the Discrete Particle Scheme - DPS) which allows us to simulate the response of fractured rocks to dynamic and quasi-static changes in stress. This model will be used to investigate how fracture structure affects its mechanical and seismic response, and how these properties scale with size. The dependence of inverted fracture properties on seismic frequency will also be investigated.